

Report for 2004NC41B: Arsenic and Heavy Metal Leaching Potential from Broiler Litter Stockpiled on Bare Soil

- Water Resources Research Institute Reports:
 - 4. Water Resources Research Institute Reports: None to report.
- Conference Proceedings:
 - 5. Conference Proceedings: None to report.
- Articles in Refereed Scientific Journals:
 - 1. Articles in Refereed Scientific Journals: None to report.
- Dissertations:
 - 3. Dissertations: None to report.
- Book Chapters:
 - 2. Book Chapters: None to report.
- Other Publications:
 - 6. Other Publications: Shah, S.B., G. Grabow, D. Hesterberg, R. Huffman, J. Parsons, K. Hutchison, D. Hardy, and B. Jackson, 2005, Poster Abstract: Arsenic and Heavy Metal Leaching Potential from Turkey Litter Stockpiled on Bare Soil, in process for 2005 ASAE Annual International Meeting, Tampa, Florida, USA.

Report Follows

Title

Arsenic and Heavy Metal Leaching Potential from Broiler Litter Stockpiled on Bare Soil (70208)

Problem and Research Objectives

Poultry production generates large amounts of waste in the form of poultry litter, a mixture of bedding material, manure, feathers, feed, and water. Frequently, poultry litter is stockpiled on bare soil close to the poultry houses or farmstead. Depending on management practice, soil and weather conditions, and crop cycle, the producer may stockpile the litter for months at the same location before land application. Soluble constituents of poultry litter stockpiled on bare soil may be transported by rainfall into the soil, both beneath and in the vicinity of the stockpile. Litter stockpiling duration and frequency, litter properties, soil properties, rainfall, and depth to the groundwater are some factors that could affect the transformation, mobility, and toxicity of poultry litter constituents, and could thus increase the potential for groundwater contamination, with potential adverse health and environmental effects. Risk of groundwater contamination by soluble poultry litter constituents is high in the Coastal Plain of North Carolina and Delaware where there are coarse-textured soils with high water tables and large poultry industries.

North Carolina ranks fourth, behind Georgia, Arkansas, and Alabama in broiler production, with >735 million broilers produced in 2002. After raising broilers for 6 weeks, the producer empties the broiler house and brings in a fresh batch of broiler chicks. Depending on the recommendations of the broiler integrator and farm management practices, some producers will replace the litter every grow-out, remove only the crusted litter after every grow-out or reuse the old litter for a number of grow-outs. While some producers employ custom applicators to remove and land-apply the litter, others will use farm labor to remove and land-apply the litter. However, due to soil and crop conditions as well as time and equipment constraints, a large number of producers stockpile litter for long durations before land-applying the litter. While storing litter in covered sheds with concrete floors reduces the potential for nutrient losses in rainfall-induced runoff and leaching, many producers stockpile litter on bare soil without any cover due to cost and flexibility considerations. Steve Rackley of Nash Johnson and Sons (poultry integrator) estimated that 95% of broiler producers stockpiled litter on bare soil (personal communication, Kenansville, N.C., 9 September 2003). In North Carolina, broiler litter is generally stockpiled over the winter months and then applied to corn ground in spring. While some producers apply broiler litter to hayfields during summer, in the absence of disposal alternatives, many producers will stockpile broiler litter for application to winter wheat in fall. Litter constituents in the stockpile could be transformed into more mobile and toxic species due to favorable litter (e.g., high dissolved organic C and microbial concentrations) and environmental (e.g., high temperature and moisture content) conditions, resulting in leaching of the compounds out of the litter stockpile. Because of the high localized concentrations of potentially-toxic

As and metals in a poultry litter stockpile, a plume of leached constituents could move through the soil and possibly impact groundwater.

While NO_3^- -N leaching from animal waste application and turkey manure piles has been identified as a source of concern to groundwater quality, no work on the impact of leaching of metals from litter stockpiles could be located. However, there is evidence of As leaching into irrigation wells due to organic As herbicides in cotton (Bednar et al., 2002). Further, litter constituents such as phosphate, NO_3^- -N, and organic C could increase transformation of As and its mobility in the soil. In the Coastal Plain, the surficial, unconfined aquifer which is usually within 6 m of the soil surface and much higher during the wetter months, could be used as a water supply source. Broiler litter stockpiling, combined with litter characteristics, and soil and environmental conditions, could result in contamination of groundwater resources by litter constituents, including metals. While this study will focus on broiler litter stockpiling, its impacts would also extend to turkey production (NC is the second largest turkey producer behind Minnesota), since management practices and litter quality are similar for broilers and turkey. Hence, the proposed study will be used to monitor transformations of As, Cu, Mn, Zn, N, and P species, and changes in total C concentrations in the litter stockpile. Further, the study will be used to evaluate leaching of As species, NO_3^- -N, ammoniacal-N, phosphate, Cu, Mn, and Zn from broiler litter stockpiled on bare soil.

The scope of the proposed research is to monitor As, N, and P transformations, and total C (for C/N ratios) concentrations within the litter stockpile and movement of litter constituents in the upper 0.9 m (3 ft) of soil beneath and adjacent to stockpiled broiler litter under both, natural and simulated rainfall. Two batches of litter will be stockpiled during the 12-month study on a site that has not been previously contaminated with animal waste or metal containing compounds. Each batch will remain on the site for ~5 months and the site will be bare for 2-3 weeks between the two batches of litter stockpiles.

The goal of the proposed research is to evaluate the potential of constituents in broiler litter stockpiled on bare soil to contaminate groundwater. The specific research objectives are:

1. to evaluate transformations of As, N, and P species and changes in total C concentrations at different depths within the stockpiled broiler litter, and
2. to monitor movement of As species, NO_3^- -N, ammoniacal-N, phosphate, Cu, Mn, and Zn beneath and around the litter stockpile.

Methodology

The project will involve field research and laboratory analyses. Field research will be conducted at NCSU's Horticultural Crops Research Station in Clinton and laboratory analyses will be performed at the Environmental Analysis Laboratory (Bio. & Ag. Engineering Dept., NCSU), Soil Physical Properties Laboratory (Bio. & Ag. Engineering Dept., NCSU), Analytical Services Laboratory (Soil Science Dept., NCSU), and NCDACS's Testing Laboratories.

Temporal changes in constituent (As species, N species, P species, carbon, Cu, Mn, and Zn) concentrations in broiler litter stockpiles as well as in underlying and adjacent soil at various depths will be investigated. Four broiler litter stockpiles will be monitored during summer through fall and four more during fall through spring; in each batch, two stockpiles will be monitored under natural rainfall and two more under simulated rainfall. Litter analyses at the beginning and end of stockpiling will provide information on the impact of stockpiling and environmental conditions on the transformation and mobility of constituents. Soil sampling in the upper 0.9 m (3 ft) of soil in different depth increments, before and after stockpiling, will provide information on the leaching of litter constituents in the soil and its potential impact on groundwater quality over time. Further information related to As mobility as influenced by soil phosphate concentrations will also be obtained.

This research will determine whether leaching of potentially-toxic groundwater contaminants, particularly As is a concern when broiler litter is stockpiled on bare soil. Environmental conditions favoring transformations of potentially harmful litter constituents into more mobile forms will be assessed. Such information could be used by state and federal agencies concerned about groundwater quality to evaluate measures to safeguard public health and the environment. If necessary, measures for reducing or eliminating any harmful impacts of poultry feed additives could be developed based on the study results.

The risk of leaching of harmful poultry litter constituents into the soil and its potential impact on groundwater would be obtained. Such information could be used in developing preventative and/or remedial measures to protect groundwater quality. State and federal agencies could work with producers currently stockpiling poultry litter on bare soil as well as those who stockpiled in the past to reduce/eliminate the potential threat to groundwater.

Correlations between plant-available constituent (P and metals) concentrations obtained with the less expensive Mehlich III extraction method vs. total concentrations obtained with more expensive methods would be developed. While correlations would only be developed for a limited number of soils, this relationship between plant-available concentrations and total concentrations may better help NC Department of Agriculture and Consumer Services (NCDACS) use Mehlich III data as an indicator of adverse environmental impacts.

Principal Findings

All soil and turkey litter samples obtained during the November 2004 sampling are being analyzed. The four new turkey litter stockpiles established in November 2004 are under observation at the field site in Clinton, NC. They could not apply simulated rainfall to two of the four stockpiles as originally proposed since the irrigation system had been winterized and there was reluctance at the Research Station to apply irrigation since the

system would again require winterization. The stockpiles were dismantled the last week of April 2005. The turkey litter and soil will be sampled as was done in November 2004.

Significance

Measures for reducing or eliminating any harmful impacts of poultry feed additives could be developed based on the study results. This information could also be used to develop preventative and/or remedial measures to protect groundwater quality. While correlations would only be developed for a limited number of soils, this relationship between plant-available concentrations and total concentrations may better help NC Department of Agriculture and Consumer Services (NCDACS) use Mehlich III data as an indicator of adverse environmental impacts.